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(54) METHOD OF PROCESSING BITUMINOUS FROTH RECOVERED FROM TAR SANDS (III)

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ABSTRACT OF THE DISCLOSURE

A method of recovering an improved bitumen froth from tar sands utilizing the hot water extraction of the tar sands to recover a primary bitumen froth which is thereafter upgraded to a petroleum refining feed stock. A procedure for removing mineral matter and water from the primary bitumen froth recovered from tar sands which comprises settling the primary bitumen froth in a settler zone to provide a froth product substantially reduced in mineral matter and water, a tailings product, and a water product. The tailings product is thereafter subject to centrifugal force to provide a centrifugal tailings product and a centrifugal froth product. The centrifugal froth product is recycled to the settler zone, providing a substantially improved bitumen froth suitable for petroleum refining.

The present invention relates to a process for the improvement of bitumen froth recovered by the hot water process for separating bitumen from bituminous tar sands. The present invention, more particularly, relates to a method wherein the final bitumen froth product recovered from the process is substantially reduced in mineral matter and water thereby providing a distinctly improved bitumen froth product suitable for coking, hydrovisbreaking or other petroleum refining techniques.

Numerous deposits of bituminous tar sands exist throughout the world. The most extensive deposits are found in Northern Alberta, Canada. The sands are composed of a siliceous material, generally having a size greater than that passing a 325 mesh screen, saturated with a relatively heavy, viscous bitumen in quantities of from 5 to 21 weight percent of the total composition. More typically, the bitumen content of the sands is between 8 to 15 percent. This bitumen is quite viscous and contains typically 4.5 percent sulfur and 38 percent aromatics. Its specific gravity at 60°F. ranges typically from about 1.00 to about 1.06. The tar sands also contain clay and silt. Silt is defined as material which will pass a 325 mesh screen but which is larger than 2 microns. Clay is material smaller than 2 microns including some siliceous material of that size.

There are several well-known procedures for effecting separation of bitumen from tar sands. One particularly effective method is that disclosed in Canadian Patent 841,581 issued May 12, 1970 to Paul H. Floyd etal. The method of this disclosure provides that the bituminous sands are jetted with steam and mulled with a minor amount of hot water at a temperature in the range of 140°-210°F. in a conditioning drum.

Monovalent alkaline reagent can also be added to the conditioning drum usually in amounts of from 0.1 to 3.0 lbs. per ton of tar sands. The amount of such alkaline reagent preferably is regulated to maintain the pH of the middlings layer in a subsequent separator zone within the range of 7.5 to 9.0. Best results seem to be obtained at a pH value of 8.0 to 8.5. The amount of the alkaline reagent that needs to be added to maintain a pH value in the range of 7.5 to 9.0 may vary from time to time as the composition of the tar sands as obtained from the mine site varies. The best alkaline reagents to use for this purpose are caustic soda, sodium carbonate or sodium silicate, although any of the other monovalent alkaline reagents can be used if desired.

Mulling of the tar sands produces a pulp which then passes from the conditioning drum to a screen. The purpose of the screen is to remove from the tar sand pulp any debris, rocks or oversized lumps. The pulp then passes from the screen to a sump where it is diluted with additional water including middlings recycle stream from the separation cell. Recycling of the middlings is not essential in all cases, particularly when the clay content of the tar sands is high. In this event a relatively high rate of fresh feed water is employed to compensate for the high clay content while a correspondingly high rate of transfer of middlings layer to a secondary scavenger zone can be maintained.

The process as above described can also include sending a minor portion of the middlings recycle stream to the conditioning drum to supply all or a part of the water needed therein other than that supplied through condensation of the steam which is consumed. Also, a stream of the middlings recycle is sometimes introduced into the screen to flush the pulp therethrough and into the sump. As a general rule the total amount of water

added to the natural bituminous sands as liquid water and as steam prior to the separation step is in the range of 0.2 to 3.0 tons per ton of the bituminous sands. The amount of water needed within this range increases as the silt and clay content of the bituminous sand increases. The resulting pulp is thereafter carried into a separation cell maintained at a temperature of about 150-200°F.

In the separation cell, sand settles to the bottom as tailings and bitumen rises to the top in the form of an oil froth which is the primary bitumen froth product. An aqueous middlings layer containing some mineral and bitumen is formed between these layers. A scavenging step is normally conducted on this middlings layer in a secondary flotation zone normally referred to as a scavenger zone. In the scavenger zone the feed material is aerated so as to produce a scavenger froth product and a scavenger tailings product. The scavenger cell froth product normally contains substantially high water and mineral matter and is thereafter treated in accordance with the procedure disclosed in Canadian Patent 857,306 issued December 1, 1970 to Ernest W. Dobson. This method comprises passing the scavenger froth to a settling zone wherein a froth product rises to the surface and the mineral matter within the froth product settles to the bottom of the settler zone. The froth product from this settling zone is thereafter combined with the froth product from the heretofore disclosed primary separation zone and subsequently combined with a diluent to provide a bituminous froth product suitable for further treatment prior to upgrading to synthetic petroleum crude.

Heretofore this froth product recovered as a combination of the primary separation zone froth and the settled

scavenger zone froth has been disclosed to be upgraded by a series of one or more centrifuges wherein the amount of mineral in the centrifuged bitumen product is about 1 to 2 weight percent. When the bitumen is later coked to produce synthetic crude, the minerals are concentrated to about 7 to 8 weight percent in the coke. This large quantity of mineral matter is generally undesirable and renders the product somewhat difficult to recover. In one type of commercial operation, this coke is burned to provide power. When the coke is burned in boilers, the contained minerals form ash which must be removed to keep the boiler tubes from fouling. Excessive quantities of minerals reduce operational ability and require expensive maintenance and air pollution preventative equipment.

Heretofore efficient and economical procedures which provide high volume production of substantially mineral-free and water-free bitumen froth from raw bitumen froth have been overlooked. By way of the present invention, a new procedure for recovering a substantially water-free and mineral-free bitumen froth product from a raw bitumen froth product produced by the hereinbefore disclosed hot water separation procedure for recovering bitumen from tar sands is provided.

By the method of the present invention, the diluted raw bitumen froth product is first transferred to a secondary settling zone which provides a diluted bitumen froth product substantially reduced in mineral and water content. The improvement of the present invention lies in the combination of diluted froth from the hot water separation process with the diluted froth recovered from the centrifuged tailings recovered from the secondary settler. By this procedure substantial

improvement in economics are realized while maintaining high volume upgrading of raw bitumen froth. To clearly define the method of the present invention, the following disclosure is presented.

Now referring to the drawing, bituminous tar sands are fed into a hot water extraction system through line 1 where they first pass to a conditioning drum or muller 3 combined with water and steam which are introduced via line 2 and mixed with the sands. The total water introduced at this point is a minor amount based on the weight of the tar sands processed and generally is in the range of 10 to 40 percent by weight of the mulled mixture.

In the normal commercial operating procedure, this water can be middlings which are recycled from separation zone 12 hereinafter disclosed and returned to conditioning drum via a means not shown. This recycling effects a substantial savings in fresh water used in the process. Mulling of the tar sands produces a pulp which then passes from the conditioning drum 3 as indicated by line 4 to a screen indicated as 5. The purpose of screen 5 is to remove from tar sands pulp any debris, rock or oversized lumps in the direction as indicated by arrow 6. The pulp passes from screen 5 as indicated via line 7 to a pump sump 8 wherein it is diluted with addition al fresh water from 9 and which also can be a middlings recycle as indicated by line 10. The diluted pulp is then transferred by way of line 11 to the primary separation zone 12. The settling zone in separator 12 is relatively quiescent so that the oil froth rises to the top and is withdrawn via line 13 while sand settles to the bottom as a tailings layer which is withdrawn through line 14.

A middlings layer which contains some oil that failed to separate is withdrawn from the cell via line 15 to a flotation scavenger zone 16. In this zone air flotation operation is conducted to cause formation of additional oil froth which passes from scavenger zone 16 through line 17 to a froth settler zone 18. An oil-lean water middlings stream is removed and discarded from the bottom of scavenger zone 16 via line 19. In the settler zone 18, the scavenger froth forms into a lower layer of settler tailings which is withdrawn and recycled via line 20 to be mixed with oil-rich middlings for feed to the scavenger zone 16 via line 15. In the settler zone an upper layer of upgraded bitumen froth forms above the tailings and is withdrawn via line 21 and mixed with the primary froth from line 13 and further combined with diluent which is added via line 22.

The bitumen product to this point can be described as a raw bitumen froth which normally comprises 20 to 45 percent and more typically 30 percent water, 2.0 to 6.0 and more typically 3.0 to 5.0 percent mineral and the remainder comprising hydrocarbon made up of the bitumen froth and the hydrocarbon diluent which has been added. The combined froths are at a temperature of about 160°F. They are heated with steam to a temperature in the range of 100-220°F. and have been diluted with sufficient naphtha or other diluent to reduce the viscosity of the bitumen for centrifuging. Generally, the weight ratio of diluent to bitumen (D/B) in the combined froths lies within the range of between 0.3 to 1.0. The raw bituminous froth containing these high concentrations of mineral matter and water is not suitable for typical refinery processing and therefore must be further upgraded to reduce mineral matter and water to substantially low concentrations. In the process of the present invention, this end is accomplished in an economic and efficient manner.

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Now referring again to the drawing, the raw diluted bitumen froth is transferred via line 23 to line 24 wherein it is combined with hereinafter disclosed bitumen froth recovered from scroll centrifuge 30. The combined diluted froths are transferred to settler zone 25 wherein the product is permitted to settle for the time necessary to provide separation of the basic constituents of the feed so that bitumen rises to the surface of the settling zone. The mineral matter containing some bitumen settles to the bottom of the zone with an intermediate water layer containing minor quantities of mineral matter separating the bitumen at the top of the settling zone from the mineral matter containing some bitumen at the bottom of the settling zone. The water layer of settler vessel 25 is withdrawn via line 26 and discarded or recycled to the extraction process. The bottoms of settler zone 25 are withdrawn via line 27 and combined with diluent added via line 28 into line 29 which carries the diluted bottoms to scroll centrifuge 30. The diluent added at line 28 can be hydrocarbon liquid usually similar to that added via line 22. The diluent to tailings ratio (D/T) is normally in the range of 0.5 to 5.0 volume of diluent per volume of tailings.

The feed from line 29 is separated via centrifuging in scroll centrifuge 30 to produce a tailings comprised substantially of mineral matter and water and a froth product. The tailings stream is withdrawn from the centrifuge via line 31 and discarded. The froth product is withdrawn via line 32 and thereafter combined with the diluted bitumen froth of line 23 in line 24 and recycled to settler vessel 25.

A bituminous froth product, substantially free of mineral matter and water, is recovered from the upper zone of settler vessel 25 via line 33. Typically, this final bitumen froth product contains at least 96 percent hydrocarbon and

no more than 0.5 percent mineral matter and 3.0 percent water. The advantages of this froth refining technique are particularly realized in the greater volume throughput of froth as well as the improved quality of the bitumen froth product as compared to other known techniques. Equally important is the fact that substantial benefits in economics are realized by low maintenance and low capital investment costs in providing the bitumen froth refining process of the herein disclosed invention.

A method of centrifuging bituminous froth recovered from the hot water extraction technique has heretofore been disclosed in the art. The prior art discloses either a single stage or multistage centrifuging of the froth, discarding the tails and recovering the bitumen from the centrifuges. However, the prior art has not provided a procedure wherein the froth is settled in a separation zone to provide a substantially improved bituminous froth as well as the recovery of bitumen from the tailings of the settling zone. This added step of centrifuging the settling zone tailings and thereafter recycling the centrifugal froth to the settling zone provides a substantial improvement in the processing of tar sand froth both with regard to volume of froth processed as well as economic advantages obtained by the processing technique.

As a means for comparing the improvements embodied in the method of the present invention with the procedures practiced in the multiple stage centrifuging disclosed in the prior art, the following examples are presented.

Example I

A diluted bituminous froth recovered from tar sands by the hereinabove described hot water extraction technique and of the composition 70 percent by weight hydrocarbon, 26.4 percent by weight water and 3.6 percent by weight mineral matter was fed to a scroll centrifuging step at the rate of 3870 B/H. This step produced a mineral tailings which was discarded and a froth product which was subsequently fed to a disc centrifuging step wherein water and mineral matter were removed and discarded and a bituminous froth product of 2890 B/H was recovered. The recovered froth product upon analysis was shown to contain 92.8 weight percent hydrocarbon, 6.0 weight percent water and 1.2 weight percent water. Although the scroll centrifuging step of this process was capable of accommodating a froth feed of higher volume, the low volume of froth which could be accepted by subsequent disc centrifuging step provided a limitation on the volume of froth which could be processed by this procedure.

Example II

Diluted bitumen froth identical to that disclosed in Example I is combined with a hereinafter disclosed scroll centrifuge froth product and fed to a settling zone at the rate of 9,200 barrels per hour (B/H). In the settling zone a lower tailings layer comprising bitumen, mineral matter and water is formed, an upper froth layer substantially reduced in mineral matter and water is formed and a middlings layer consisting primarily of water with minor amounts of mineral matter and bitumen being present. The lower tailings layer is withdrawn and combined with hydrocarbon diluent and transferred to a scroll centrifuging step. In the scroll

centrifuging step, a tailings product consisting mainly of mineral matter and water is withdrawn and discarded. A scroll centrifuge froth is also withdrawn and recycled to be combined with the fresh froth feed to the settling zone heretofore disclosed.

The water layer is withdrawn from the settling zone and can be discarded or recycled to any step where fresh water is required. A bitumen froth product is withdrawn from the settling zone at a rate of 6330 B/H. The bitumen froth product recovered is characterized as containing 96.2 weight percent hydrocarbon, 3.5 weight percent water and 0.3 weight percent mineral matter.

A comparison of the results achieved by the process of the present invention as compared to the series centrifuging of the prior art clearly illustrates the distinct advantages enjoyed by use of this process. Specifically, higher volume of froth processed as well as a substantially improved froth product are valuable advantages achieved in the use of the method of the present invention.

The hydrocarbon diluent used in the method of the present invention is generally defined as a petroleum naphtha boiling in the range of 150°-450°F. and normally containing aromatics and saturates and can also contain olefins.

The settling vessel or vessels employed in the method of the present invention can be a cylindrical vessel normally having a closed top. Where preferred, a conical bottom including convex configurations can be employed in combination with sand rakes to aid in moving the settled mineral matter to the center of the vessel for withdrawal. The vessels are normally fitted with feed inlets mear the

middle or top of the upright portion of the vessel with bituminous bitumen froth outlets at the top of the vessel and mineral water outlets at the bottom. The central portion of the vessel, that is, the middle section between the top and bottom when in the upright position, can also contain means for removing a liquid stream such as a water layer.

Thus the present invention provides that in the hot water process for treating bituminous tar sand comprising forming a mixture of bituminous sands and water; passing the mixture into a separation zone; settling the mixture in a separation zone to form an upper primary bitumen froth layer comprising water, mineral and bitumen and a tailings layer; separately removing the primary bitumen froth layer and the sand layer; passing a stream of middlings to a scavenger zone and therein recovering a secondary bitumen froth; combining said primary and secondary bitumen froth and a diluent to form a diluted primary bitumen froth product the improvement which comprises:

(a) feeding said diluted bitumen froth combined with centrifuged froth product from hereinafter disclosed step (e) in a settling zone to provide an improved bitumen froth product layer, a water layer and a settler tailings layer;

(b) recovering the froth layer as bitumen product;

(c) discarding the water layer;

(d) diluting said settler tailings layer and thereafter centrifuging said diluted tailings layer to provide a centrifuging froth stream and

(e) thereafter recycling and combining said centrifugal froth stream with the diluted bitumen froth of step (a).

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method of removing mineral matter and water from a bituminous froth containing bitumen, mineral matter, water, and a liquid hydrocarbon diluent boiling in the range of 150° to 450°F. comprising:

(a) feeding said diluted bitumen froth combined with centrifuged froth product from hereinafter disclosed step (e) in a settling zone to provide an improved bitumen froth product layer, a water layer and a settler tailings layer;

(b) recovering the froth layer as bitumen product;

(c) discarding the water layer;

(d) diluting said settler tailings layer and thereafter centrifuging said diluted tailings layer to provide a centrifuging froth stream and a centrifugal tailings;

(e) combining said centrifugal froth stream with the diluted bitumen froth of step (a) and

(f) discarding said centrifugal tailings.

2. A method according to Claim 1 wherein the bitumen froth is maintained at a temperature in the range of 100°-220°F.

3. In the hot water process for treating bituminous tar sands which comprises: forming a mixture of the bituminous sands and water; passing the mixture into a separation zone; settling the mixture in a separation zone to form an upper primary bitumen froth layer comprising water, mineral and bitumen and a sand tailings layer; separately removing the primary bitumen froth layer and the sand layer; passing a stream of middlings to a scavenger zone and therein recovering a secondary bitumen froth; combining said primary and sccondary bitumen froth and a diluent to form a diluted primary bitumen froth product the improvement which comprises:

(a) feeding said diluted bitumen froth combined with centrifuged froth product from hereinafter disclosed step (e) in a settling zone to provide an improved bitumen froth product layer, a water layer and a settler tailings layer;

(b) recovering the froth layer as bitumen product;

(c) discarding the water layer;

(d) diluting said settler tailings layer and thereafter centrifuging said diluted tailings layer to provide a centrifuging froth stream and a centrifugal tailings,

(e) combining said centrifugal froth stream with the diluted bitumen froth of step (a) and

(f) discarding said centrifugal tailings.

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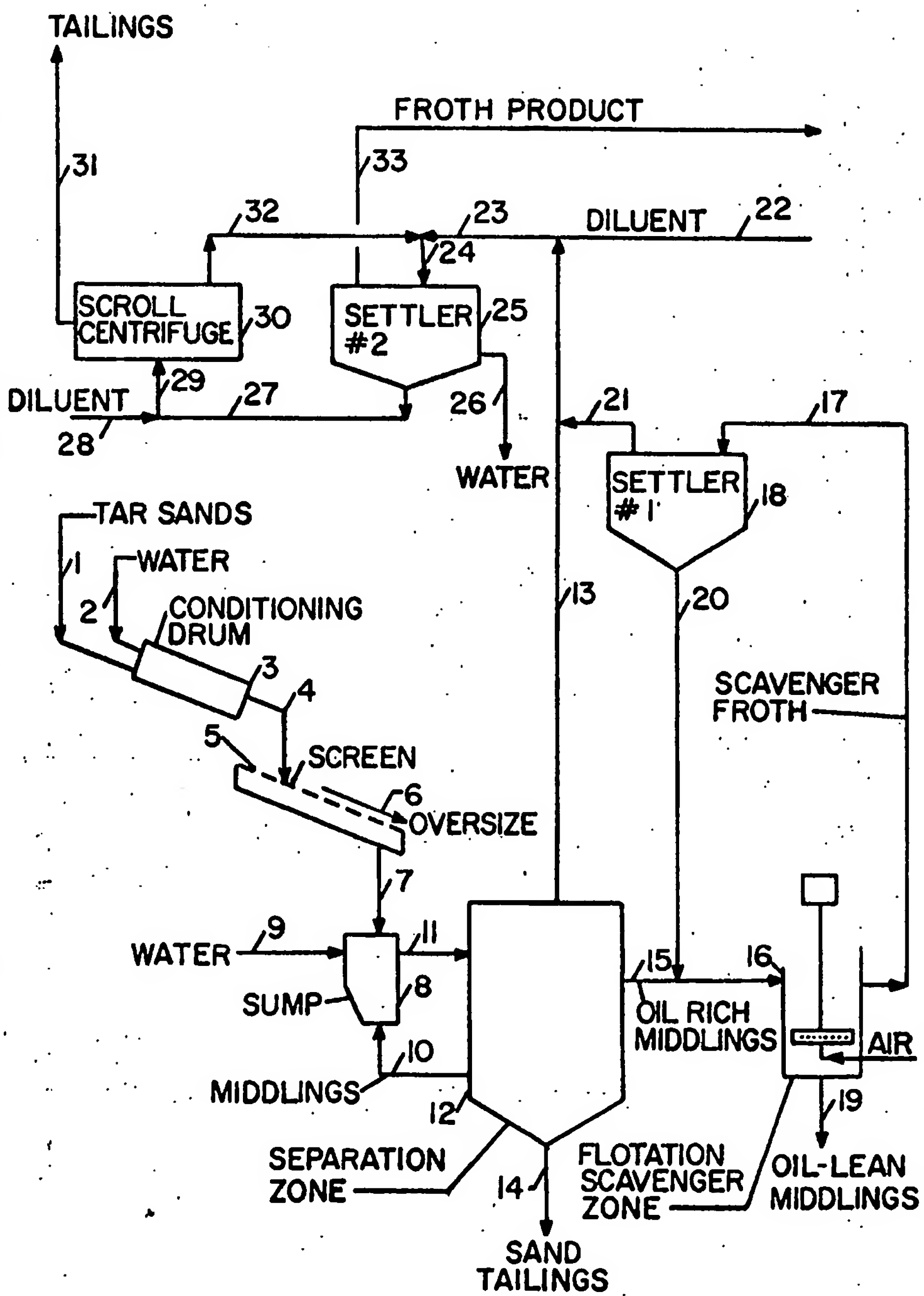
4. A method according to Claim 3 wherein the bitumen froth is maintained at a temperature in the range of 100°-220°F.



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